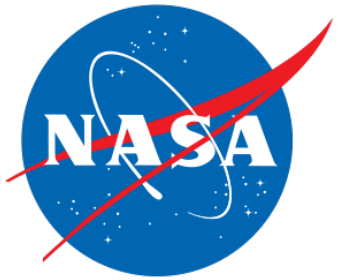
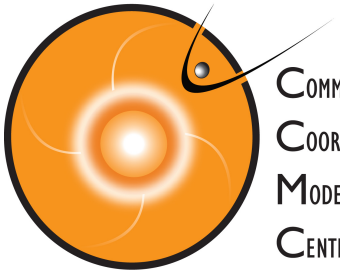


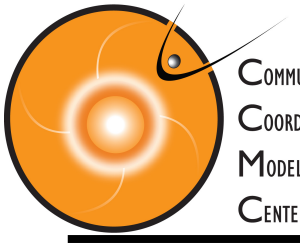

NASA
Space
Weather
Research
Center

# Sun and Its Activity

*A. Taktakishvili*

**CCMC/SWRC**

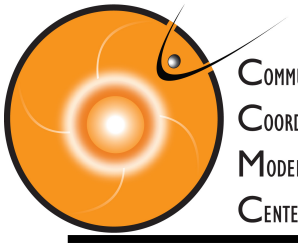
**NASA Goddard Space Flight Center**



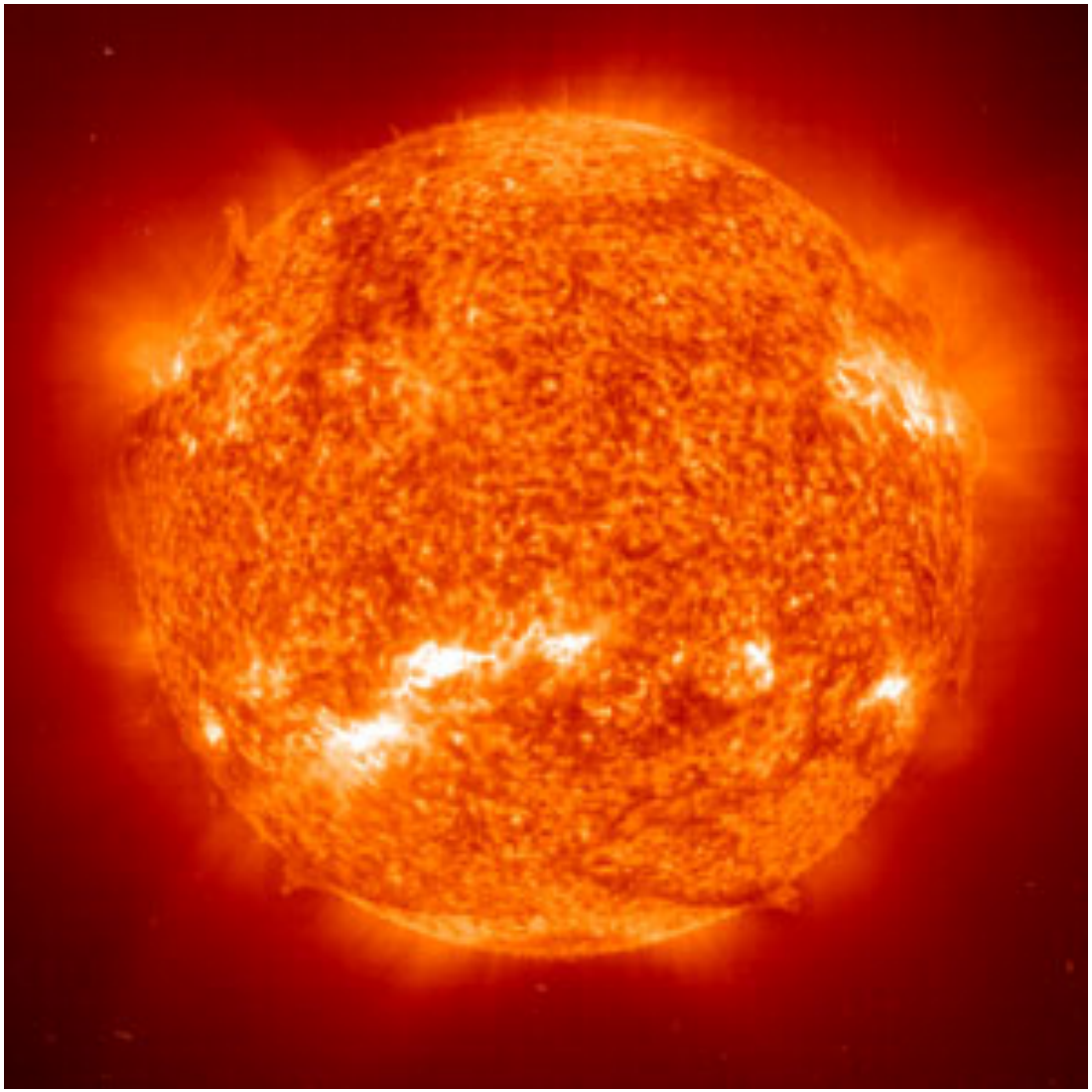

# What is Space Weather?

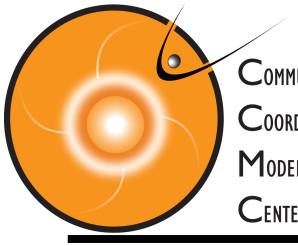
"**Space Weather** refers to conditions on the Sun and in the space environment that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health."

*National Space Weather Program Web site:*
*www.nswp.gov*




# Sun - Space Weather Driver






# Solar Wind

Solar Wind – Reaches the Earth in 4-5 days

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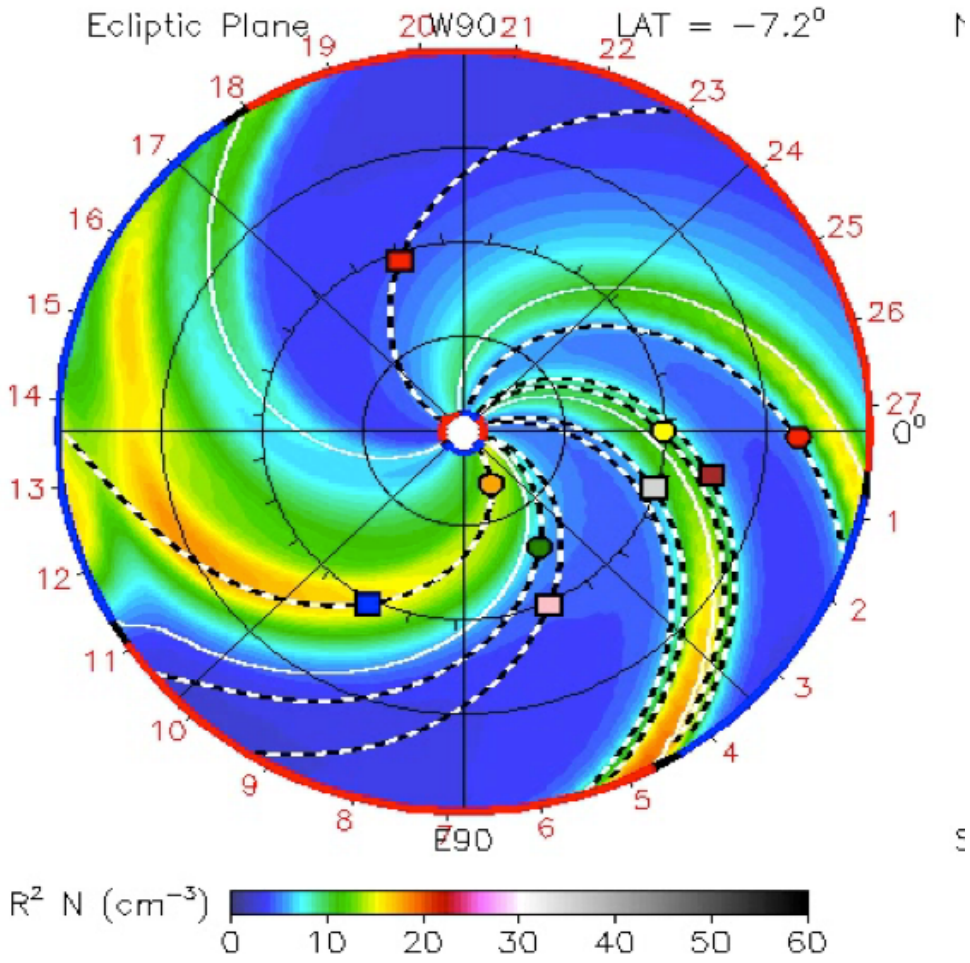
# Solar Wind

Sun like a rotating hose



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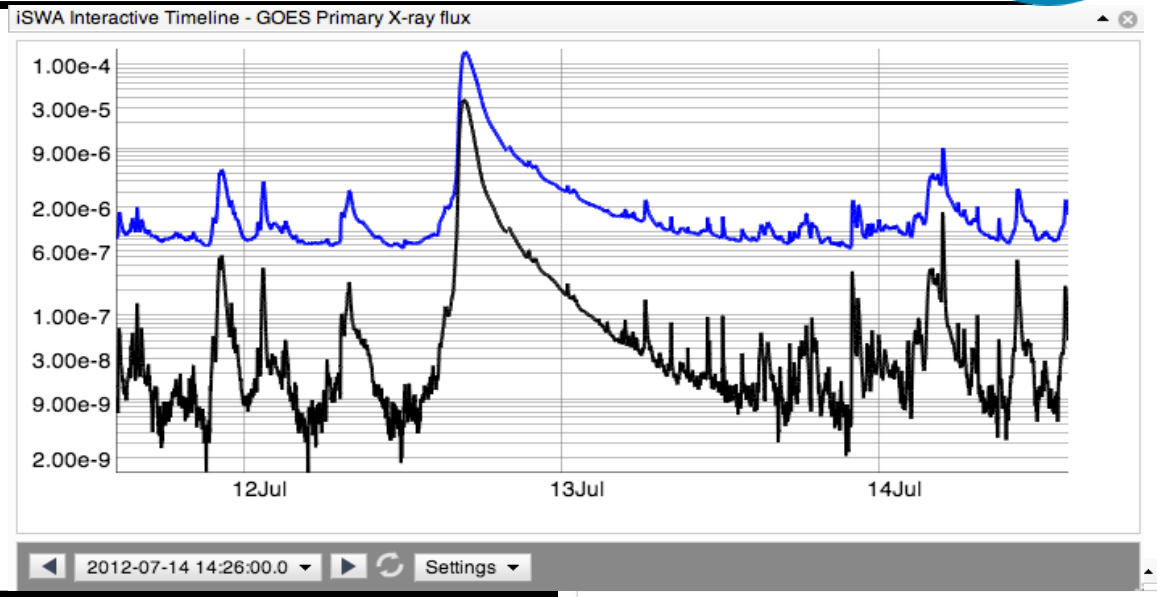
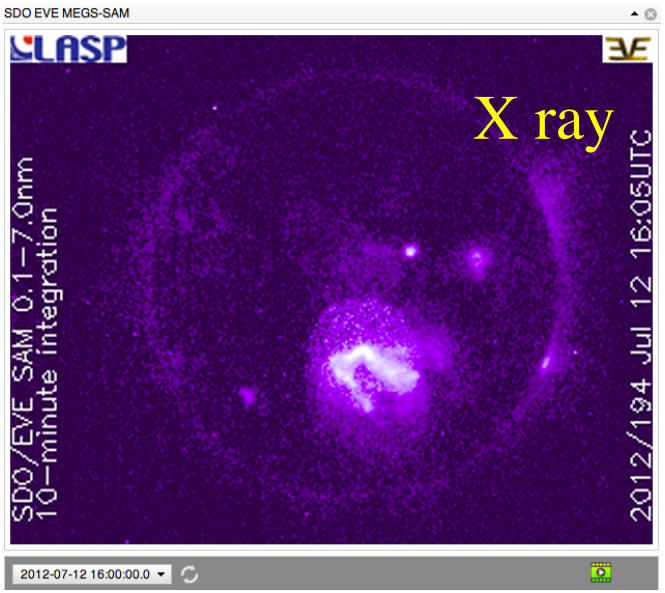
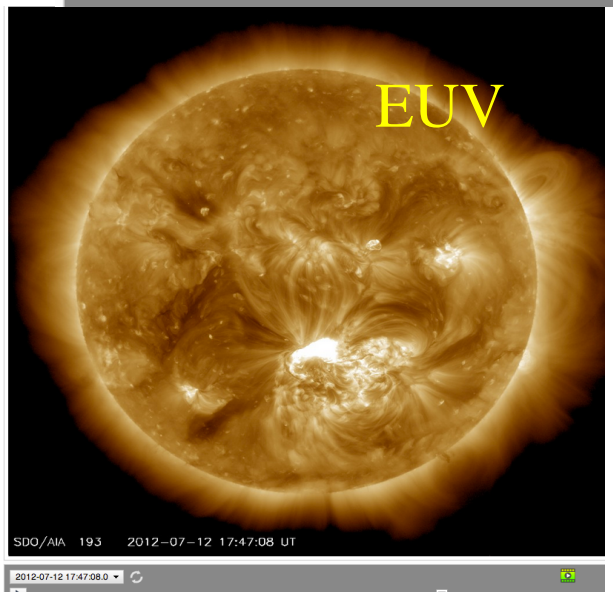
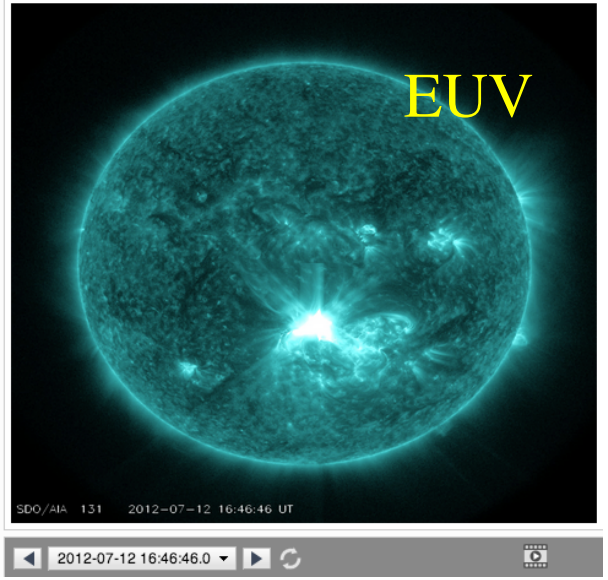
# Solar Flare

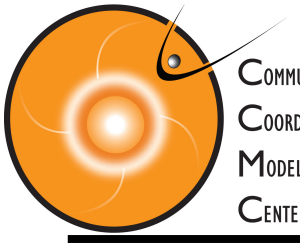
2012 July 12
X1.4 class flare



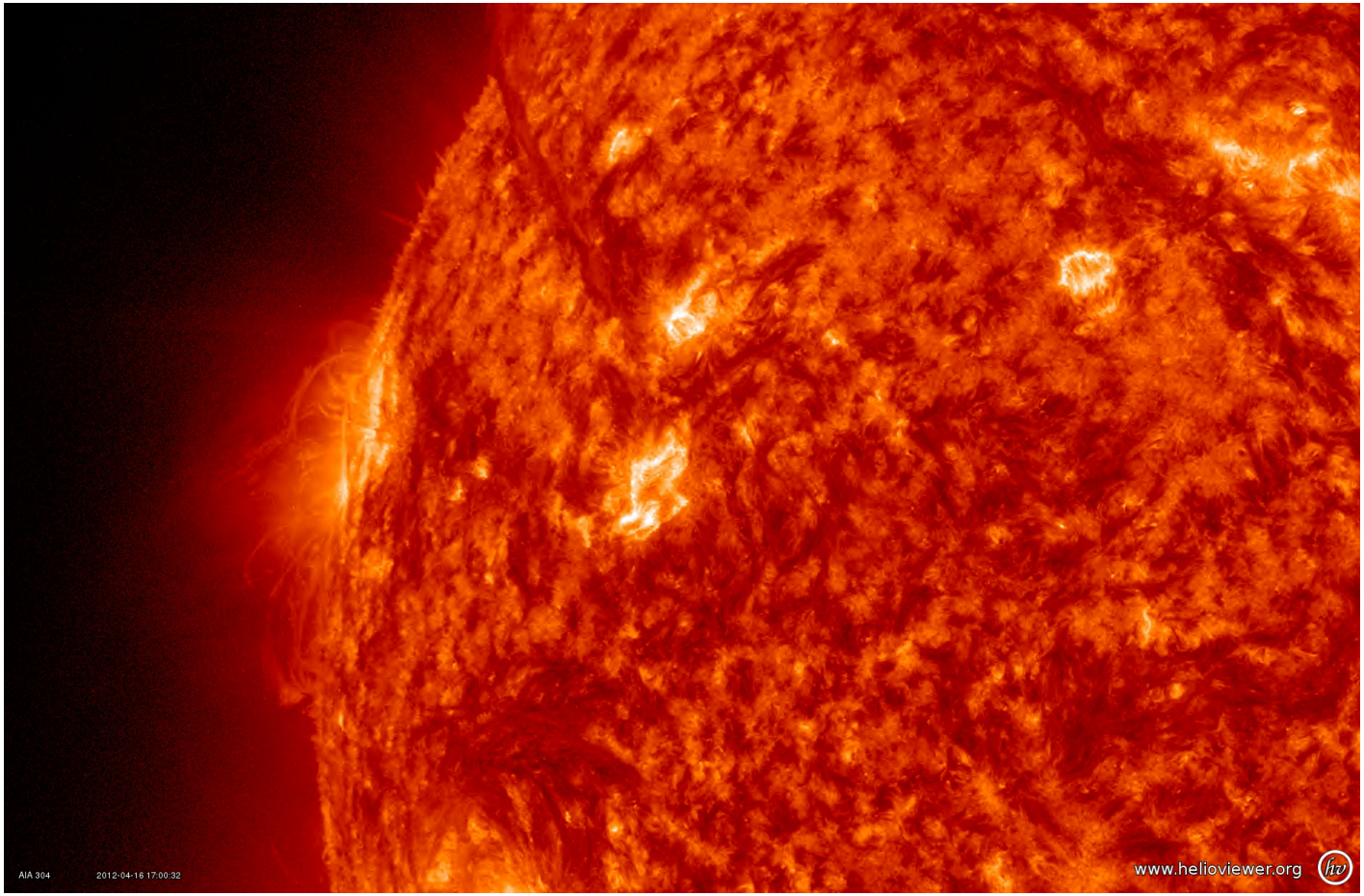



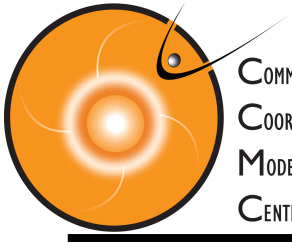






# Coronal Mass Ejection

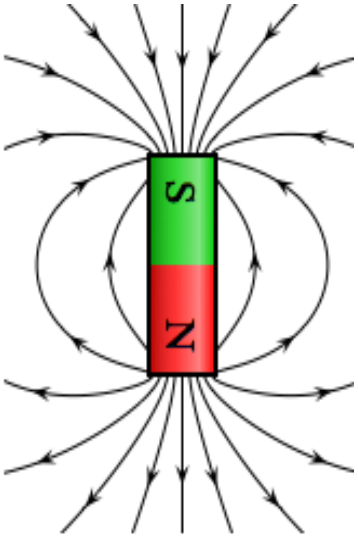
Coronal Mass Ejection – Reaches the Earth in 1-3 days

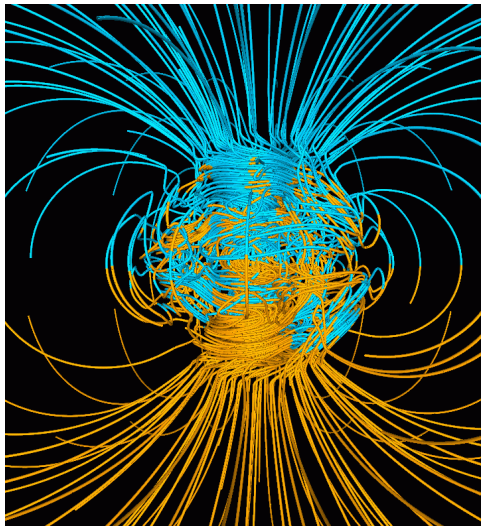


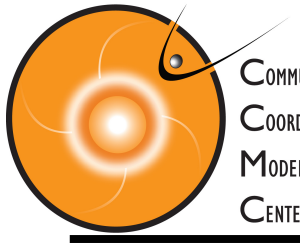



# Earth Is a Giant Magnet

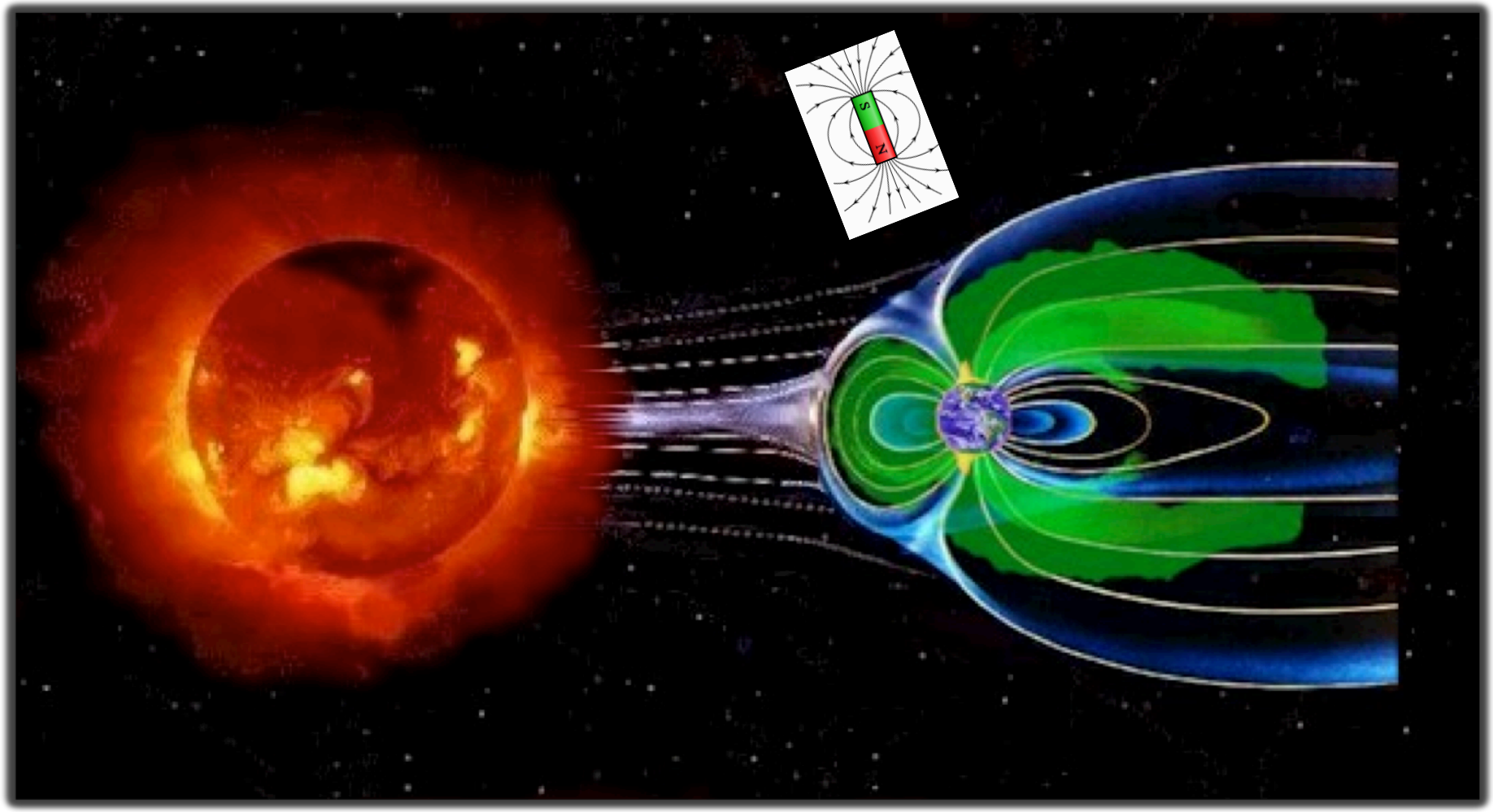
## William Gilbert (1544 – 1603)






# Earth's Magnetic Field – Our Shield



# Structure of the Sun

**Core** (up to ~ 0.25 Rs): T ~15 MK and very dense. Nuclear fusion.

**Radiation Zone** (0.25 – 0.7Rs): transparent for photons. T ~ 7 – 2 MK

**Convective zone**: (0.7 – 1.0 Rs): T is lower. Energy is transported outward mostly by *convection.*

**Photosphere** (surface): 6000 K

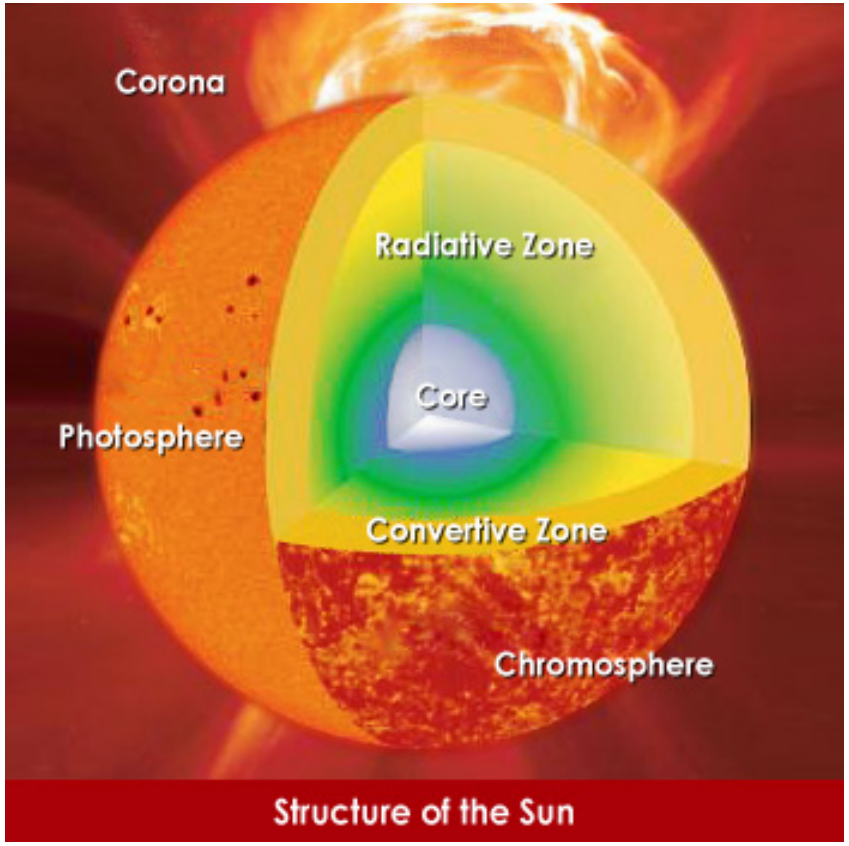
- Sunspot (typical) 4200 K

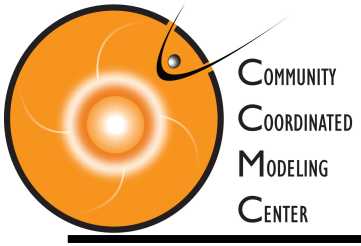
(~100 km thick).

**Chromosphere**: 20,000K (1.0Rs-2000km)

**Transition region:** 20000K – 1-2 MK (above 2000 km - no clear range)

**Corona**: 2 MK

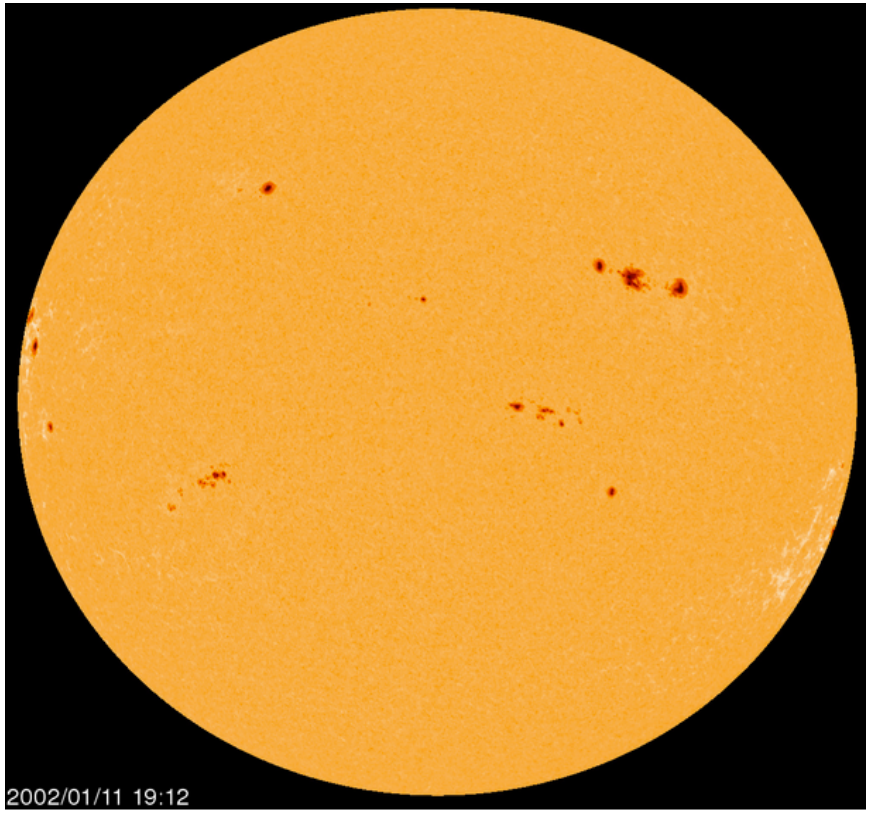




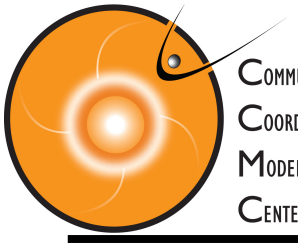

# Photosphere

The photosphere is the visible surface of the Sun that we are most familiar with.
A layer about 100 km thick (very thin compared to the 700,000 km radius of the Sun).

T ~ 6000 K
Sunspot (typical)
~ 4200 K



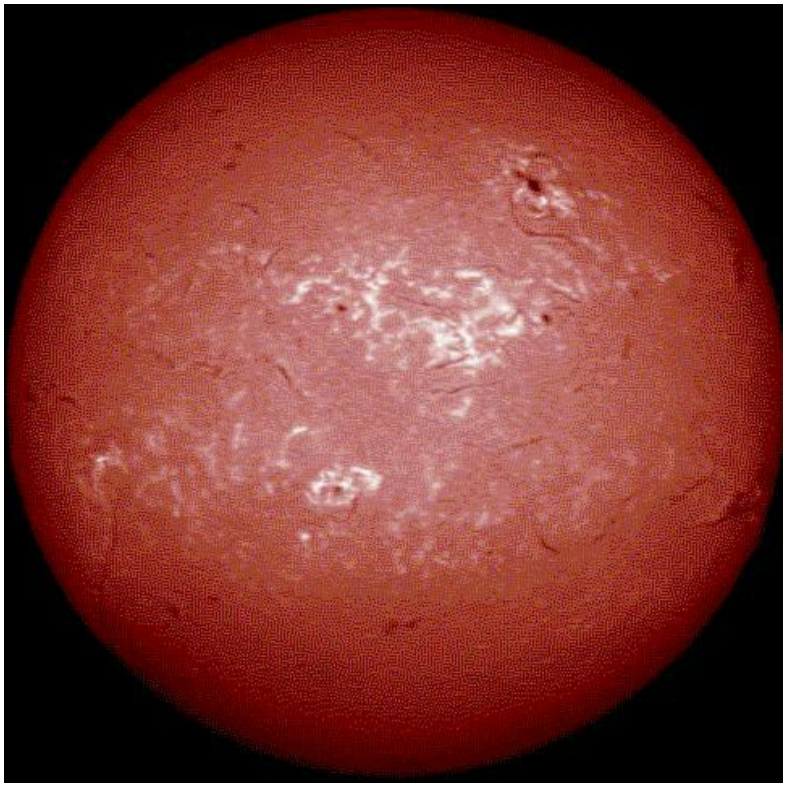

Visible spectrum:
390 - 700 nm



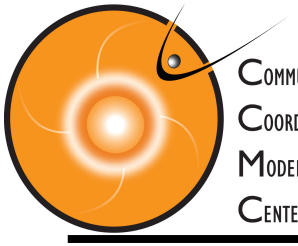

# Chromosphere

Irregular layer above the photosphere ~ 2000 km deep. The temperature rises to ~ 20,000°. Hydrogen emits light that gives off a reddish color (H-alpha emission) which can be seen in prominences that project above the limb of the sun during total solar eclipses. The chromosphere is  also the site of variation in solar flares, prominence and filament eruptions, flow of material in post-flare loops.

T ~  20 000 K



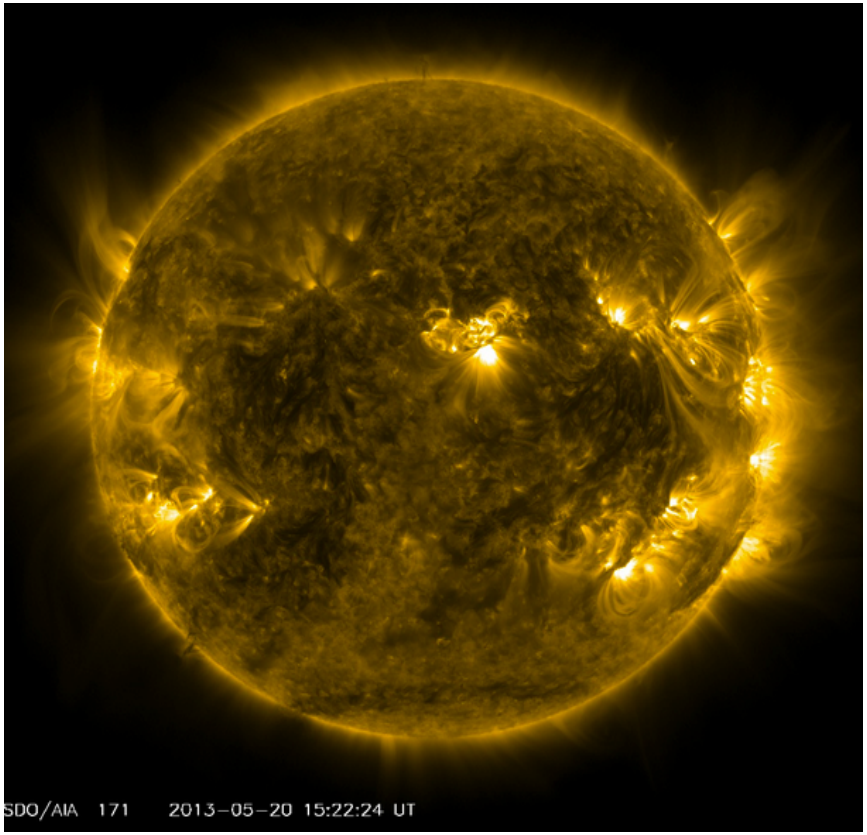
656.3 nm



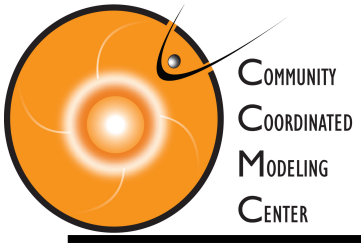

# Transition Region

The temperature rises to from 20000 to ~ 1-2 MK. Below, gravity dominates the shape of most features, so that the Sun may be described in terms of layers and horizontal features (like sunspots); above, dynamic forces dominate the shape of most features, so that the transition region itself is not a well-defined layer at a particular altitude.

T ~ 20 000 K to ~ 1-2 MK




17.1 nm

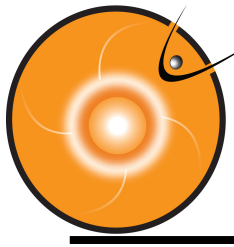



# Corona

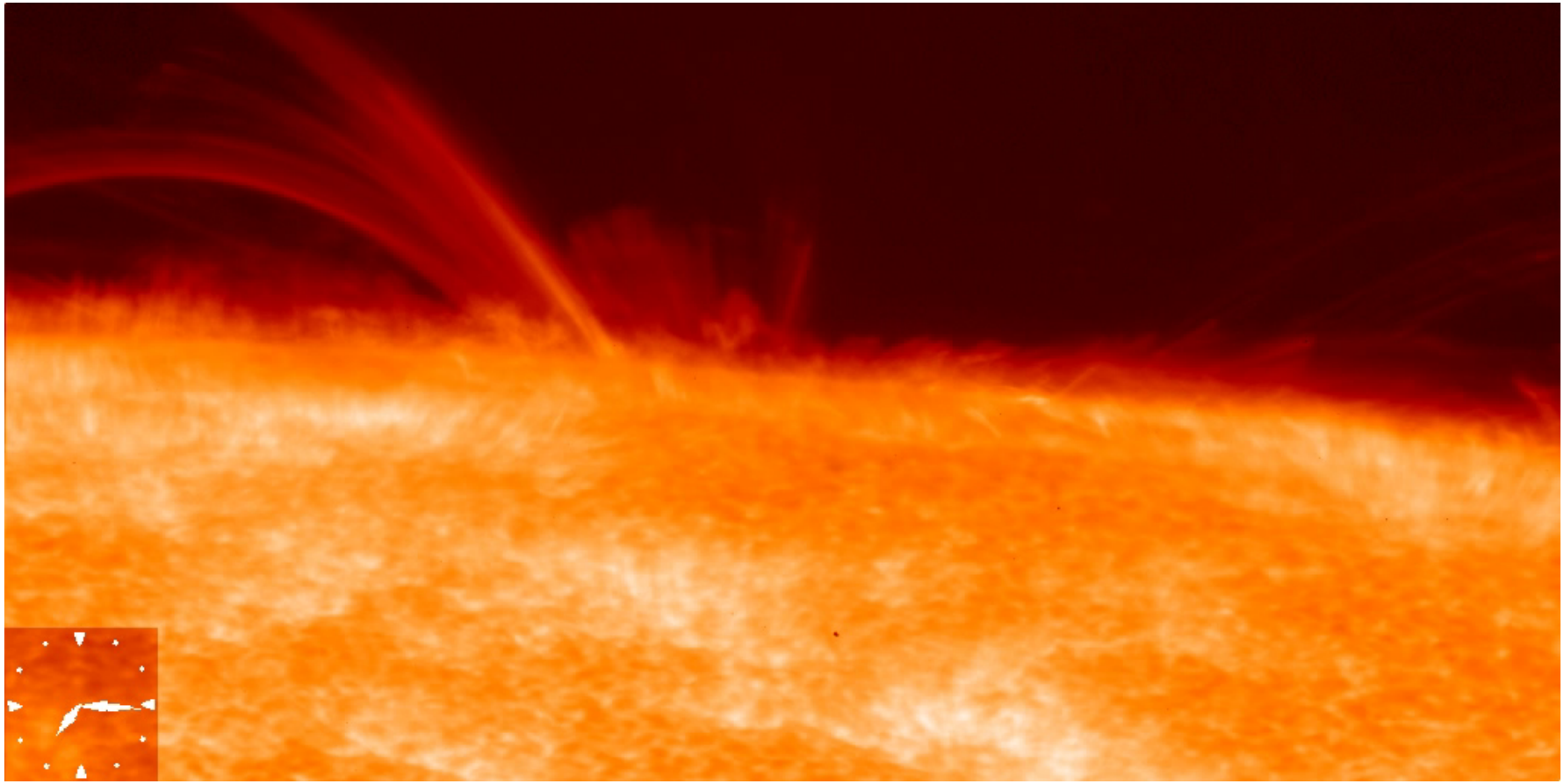
The Corona is the Sun's outer atmosphere. It is visible during total eclipses of the Sun as a pearly white crown surrounding the Sun.

T ~ 2 MK

**The heating of corona is an ongoing research area**




# Solar Activity seen by HINODE satellite



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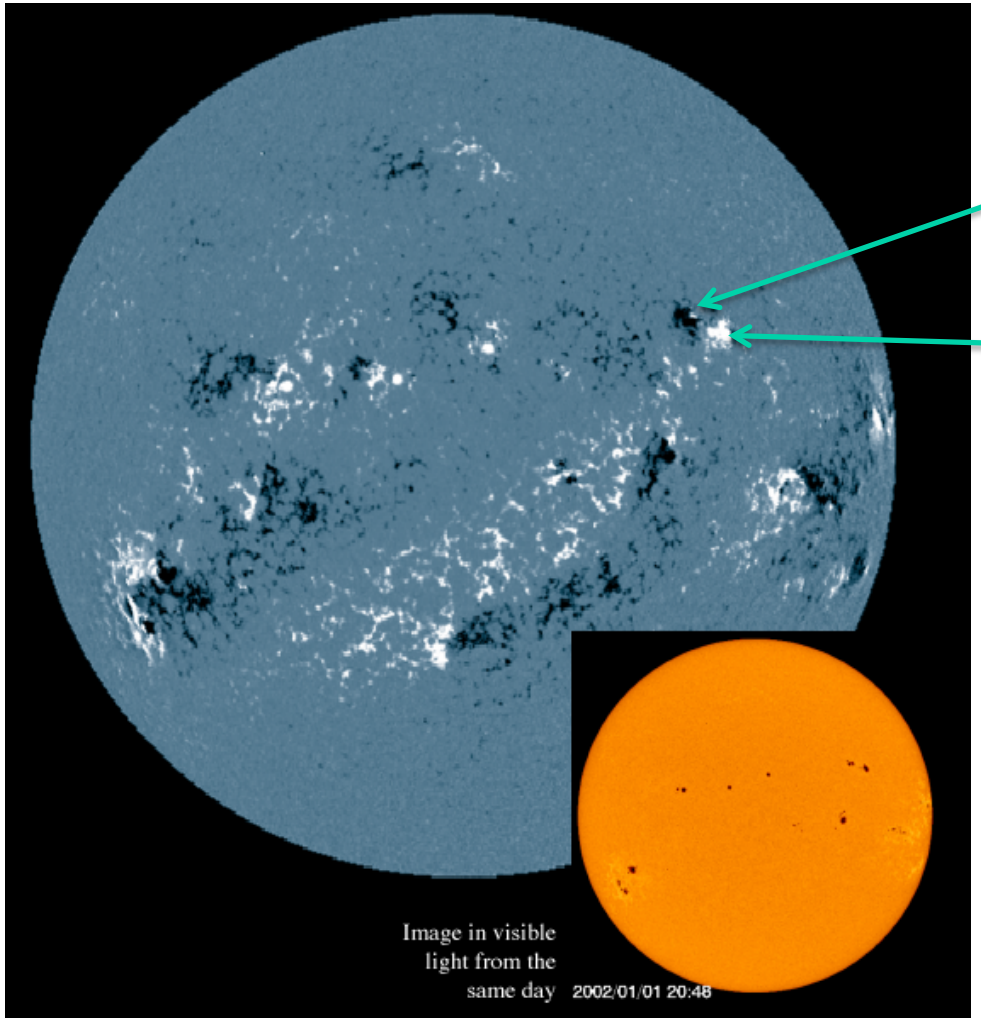
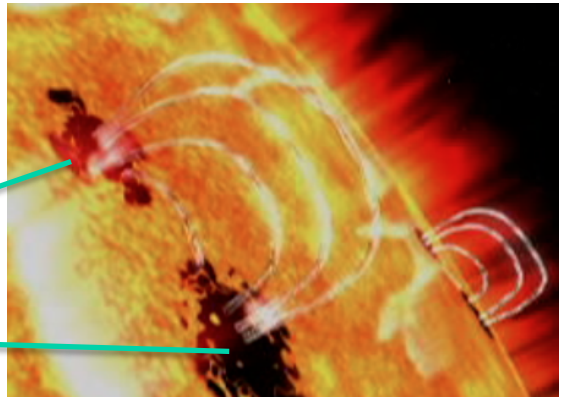
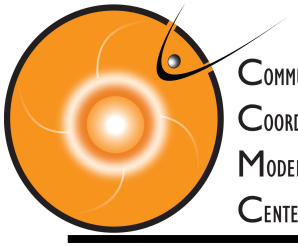
# Magnetic Field and Sunspots



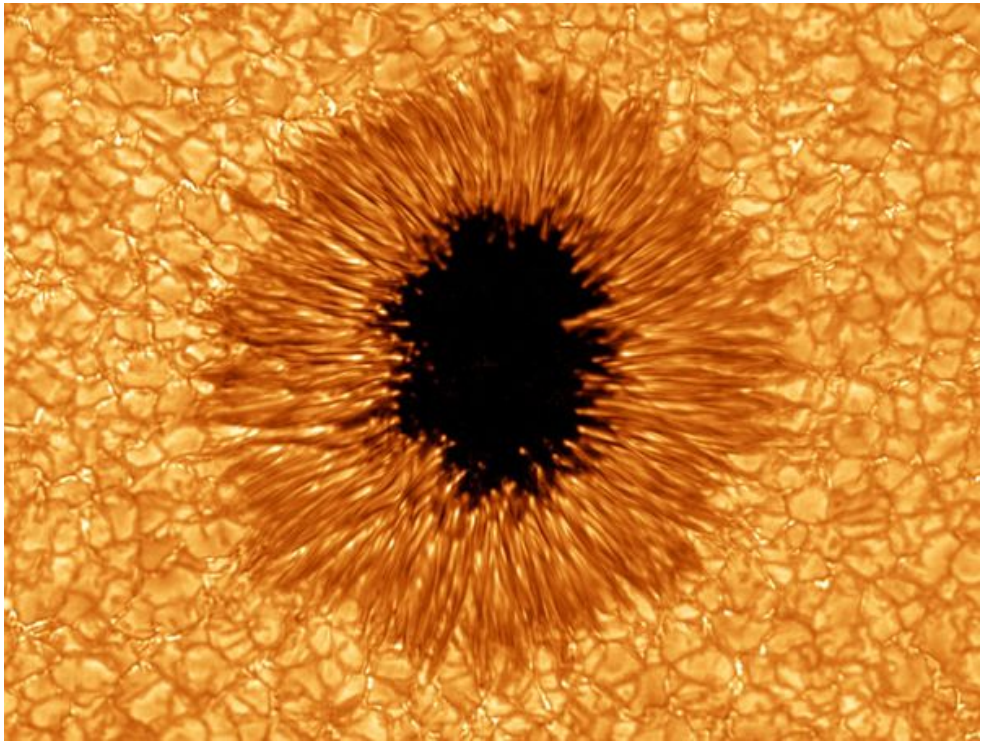



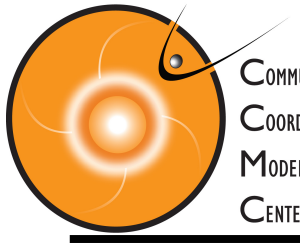
More sunspots mean more activity on the Sun.



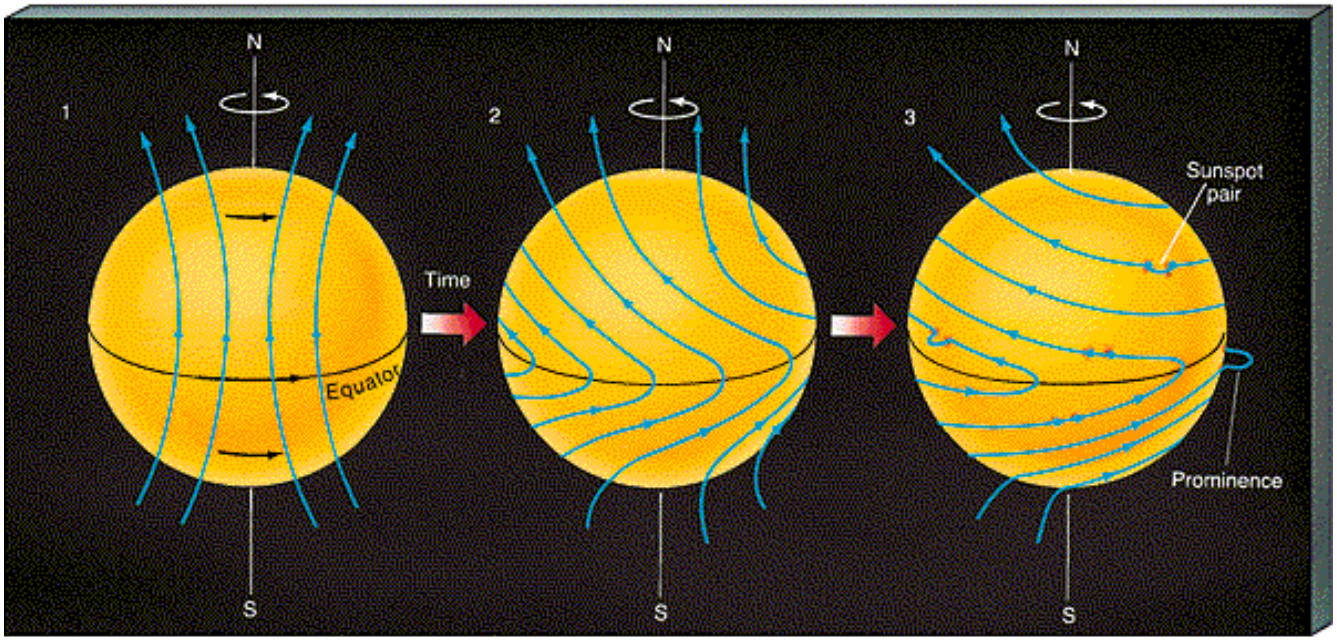

# Sunspot Close Up

Sunspots are caused by intense magnetic field inhibiting convection and leaving their temperature (~ 3000–4500 K) lower than the temperature of surrounding material ( ~ 6000) K. This makes them visible as dark spots. Size varies from 16 km to 160,000 km in diameter. Sunspots host coronal loops and reconnection events. Most solar flares and CMEs originate in magnetically active regions around sunspot groups.






# Solar Magnetic Field




Motion of the solar plasma creates the magnetic field, which in itself, as plasma moves, changes due to this motion.

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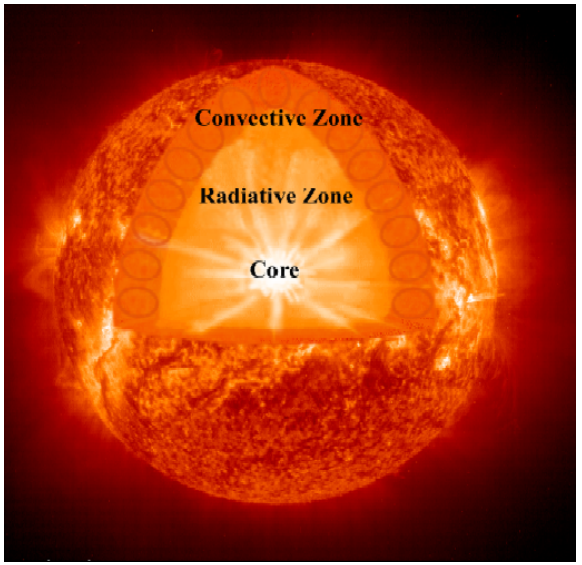
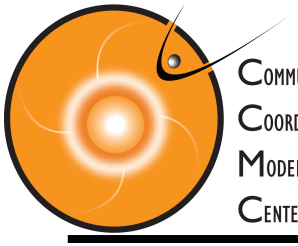
# Solar Activity is Related to Magnetic field

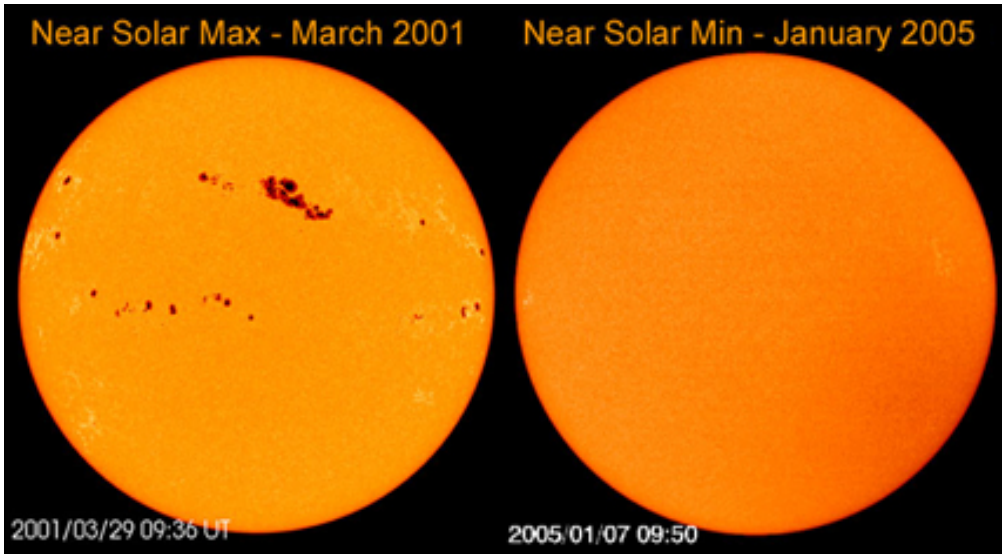
It is believed that solar magnetic field, while changing its configuration in a constantly varying solar atmosphere, releases energy, accelerating solar plasma and causing flares and CMEs.

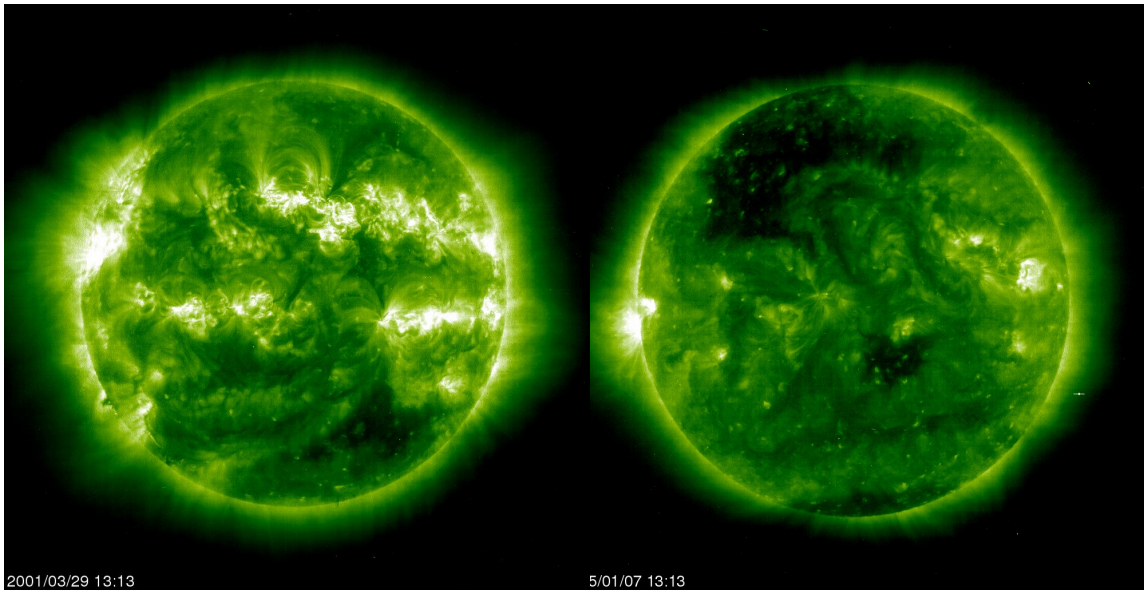



- Magnetic field is believed to be generated at the base of the convective zone
- Fields are stressed and pushed to surface, leading to flares and eruptions.




# Solar Activity
# Varies on a Large Time Scale



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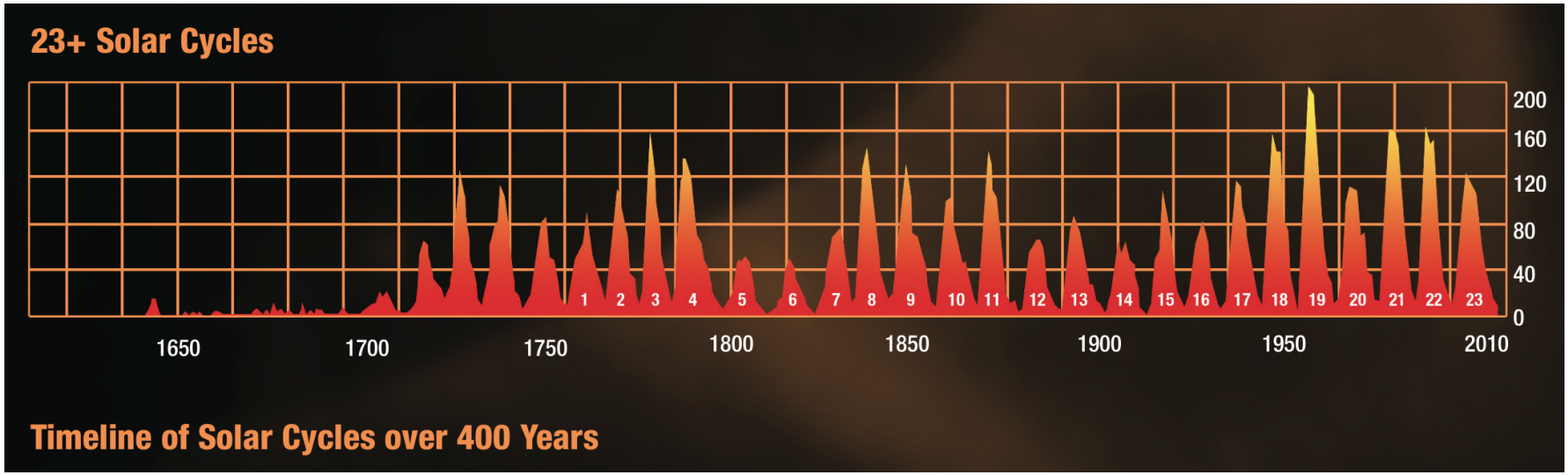
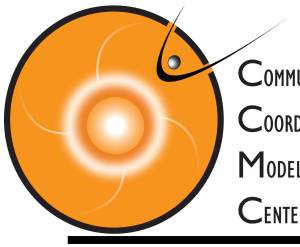
# Solar Cycles

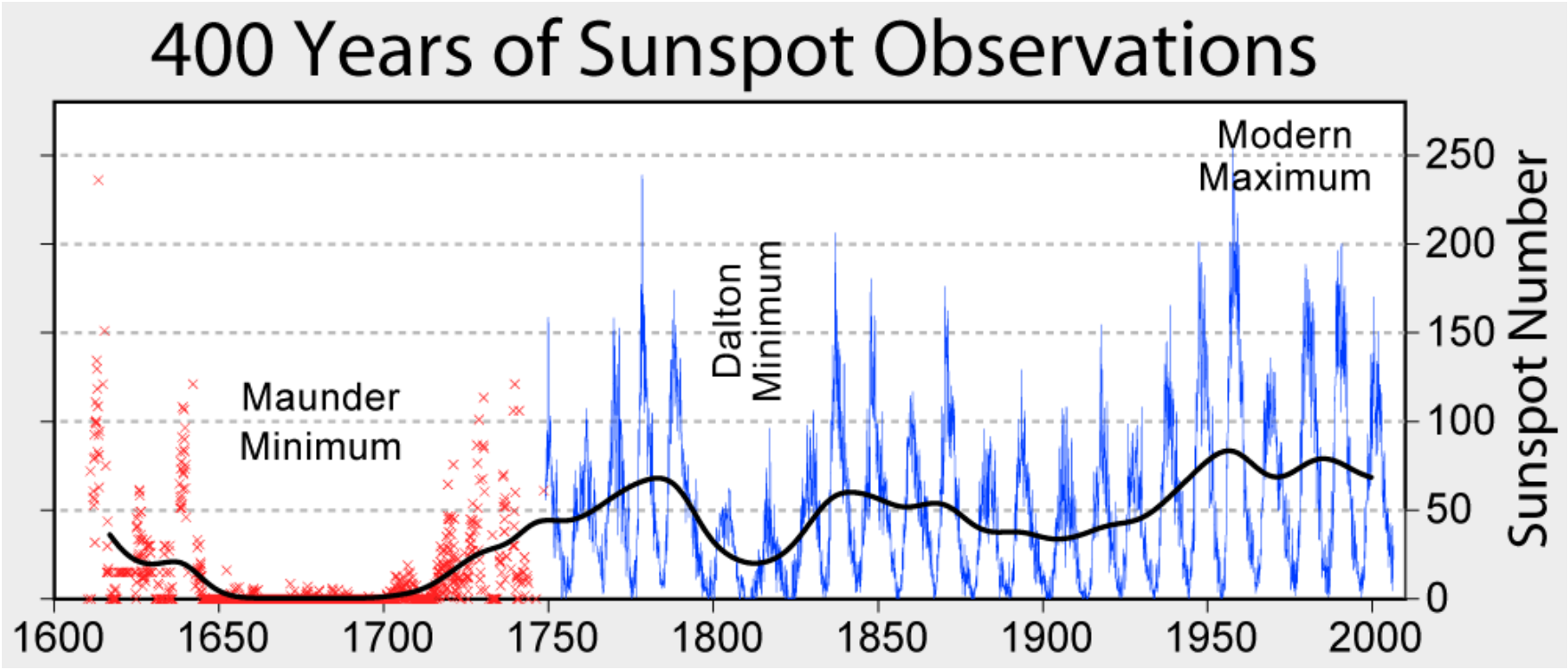
**Samuel Heinrich Schwabe**
**(1789 – 1875)**

**High and low sunspot activity repeats about every 11 years**






# Variation on Larger Time Scales



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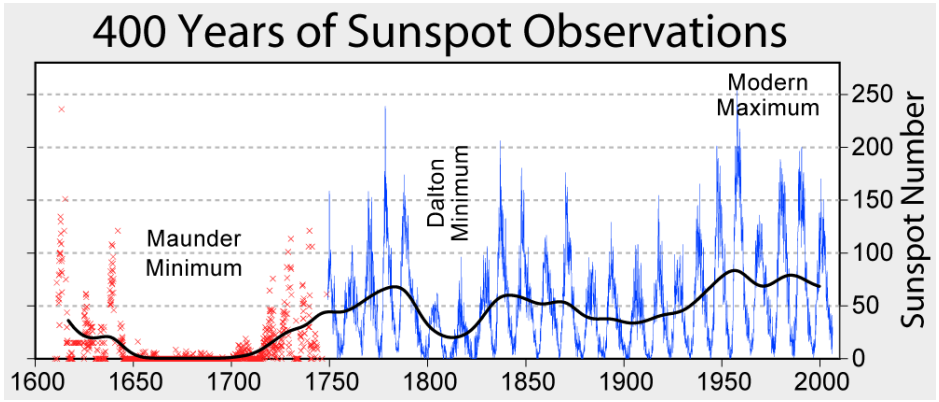
# Little Ice Age

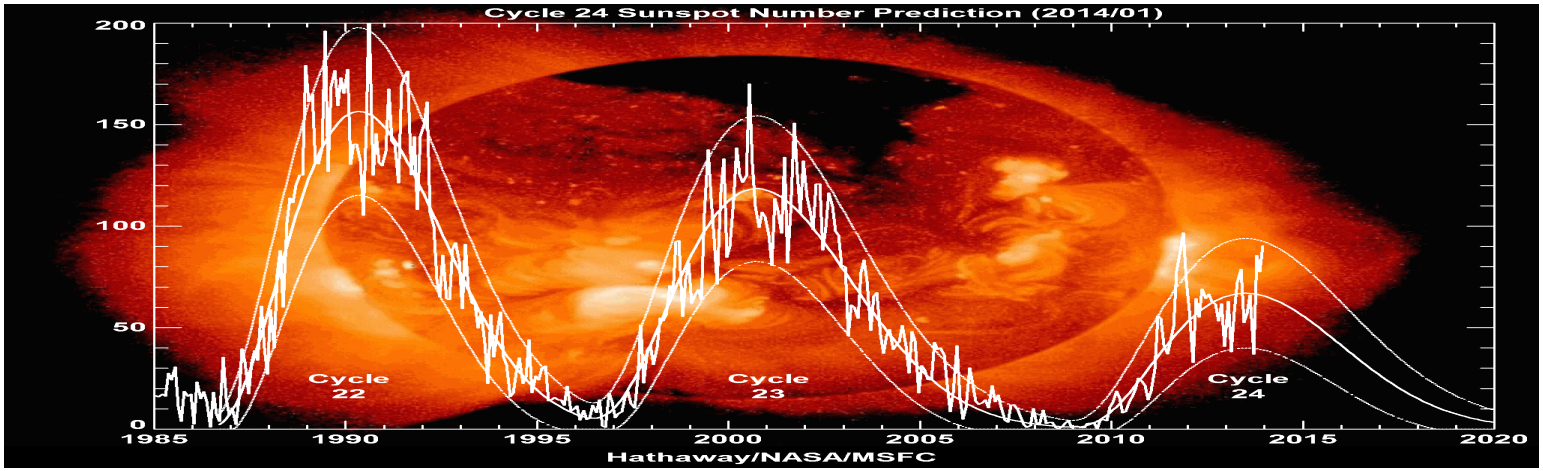


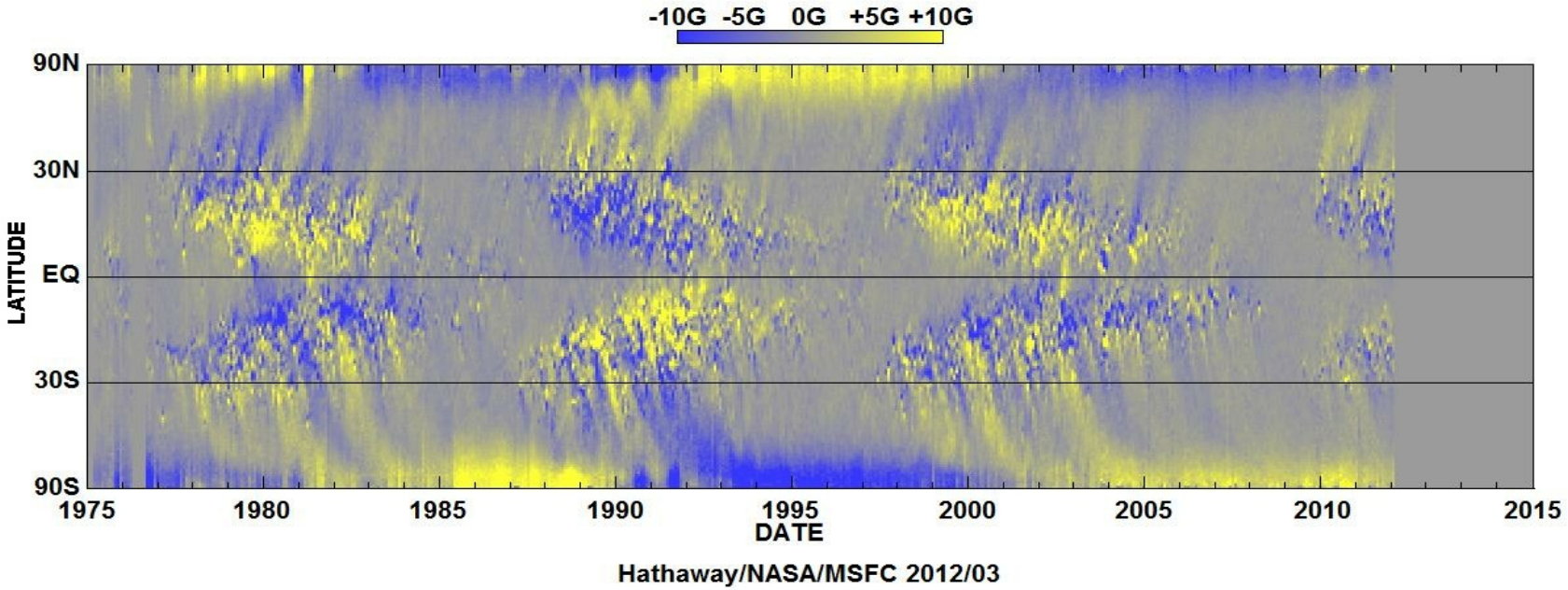

Pieter Brueghel the Elder

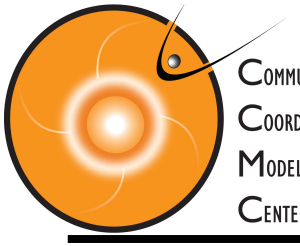
Hendrick Avercamp

Community Coordinated Modeling Center

# Solar Cycles are related to variation of Solar global magnetic field






# Current Solar Cycle 24

4-th slowest growth from the minimum ever.